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# The CLIMIT program and its strategy for Norwegian research, development and demonstration of CCS technology

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**Abstract**

The Norwegian CLIMIT program for research, development and demonstration (RD&D) of carbon capture and storage (CCS) was established in 2005 to provide financial support to RD&D of CCS technologies. Research institutions and companies in Norway together with international partners may apply to CLIMIT for funding of their projects. The program is funded by the Norwegian government with an annual budget of € 24 million. CLIMIT has so far provided € 120 million to about 200 projects covering basic research, technology development and pilot scale demonstration projects. This paper presents a new strategy for the CLIMIT program, provides some background on CCS in Norway and a brief overview of Norwegian activities within CCS. The new CLIMIT strategy is based on seven foundation reports; 1) Technology status, 2) Market analysis, 3) Cost of CCS, 4) Policies and regulations, 5) International energy and CCS roadmaps, 6) Current infrastructure and test sites and 7) Innovative processes. Major findings from these reports are presented together with the resulting CLIMIT program strategy for 2012 – 2020.



"Keywords: CLIMIT; CCS; CO2; Norway; state aid; funding; research; development; demonstration;"

## 1. Introduction and Background

Norwegian $CO_2$ equivalent emissions were 52.7 million tons in 2011, an increase by 5.8 % since 1990 [1]. The Norwegian government has set a target of 30 % reduction of $CO_2$ emissions by 2020 compared to 1990 [2]. Unlike most other countries, Norway's power sector is almost entirely based on hydropower, and only two gas power plants are on the public power grid. There are three point sources in Norway with $CO_2$ emissions greater than one million tons per year and 25 greater than 0.3 million. Many of these point

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sources are from offshore oil platforms, and together these 25 point sources account for 30 % of total emissions in Norway.

The importance of the petroleum industry in Norway largely explains Norway's involvement in CCS. There are 70 fields in production on the Norwegian Continental Shelf. In 2010 Norway was the second largest gas exporter in the world. The petroleum industry contributes 20 % of GDP, more than two times land based industries [3].

Norwegian suppliers to the petroleum industry have moved beyond the home market with competitive products and services. In 2009 suppliers to the petroleum industry saw revenues of USD 40 billion, 50 % of which were from exports [3].

IEA’s Blue Map Scenario allocates 19 % of the 2050 reduction in emissions to CCS [4]. Norwegian industry has substantial experience and competence in CCS. Two out of eight operational CCS projects worldwide are located in Norway, operated by Norwegian companies. This was triggered by the Norwegian government imposing a levy on $CO_2$ emissions from petroleum activities on the Norwegian Continental Shelf in 1991, which led Statoil to invest in CCS from the Sleipner platform in 1996. In addition, there is a potential for significant $CO_2$ storage capacity on the Norwegian Continental Shelf [5].

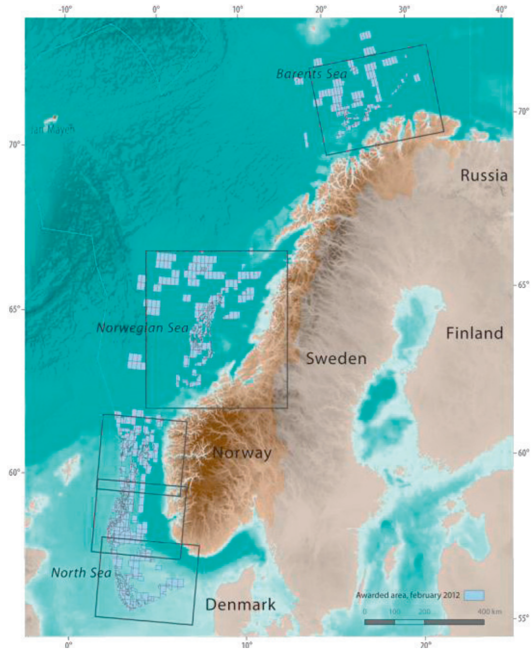


Fig. 1. The Norwegian Continental Shelf – potential offshore $CO_2$ storage capacity.

The Norwegian support for CCS aims to reduce emissions of $CO_2$ in Norway, create new business opportunities for Norwegian industries and research institutes and contribute to the development and deployment of CCS worldwide. The Norwegian government funds substantial CCS activities, such as:

- $CO_2$ Technology Centre Mongstad (TCM) [6], opened in May 2012, with a total capture capacity of 100,000 tons $CO_2$ per year, the world’s largest capture test facility
- Planning of a full scale CCS facility at the Mongstad refinery
- A comprehensive $CO_2$ storage atlas and nomination of $CO_2$ storage sites in the North Sea [5]

- CLIMIT Program for funding of RD&D of CCS technology [7].

The CLIMIT strategy process was initiated by the board of the CLIMIT program in the fall of 2010. The new strategy was developed from seven foundation reports written by CLIMIT program staff. This paper presents findings from these reports and the resulting program strategy.

## 2. The CLIMIT Program

CCS research in Norway began already in the late 1980's. In 1991 the Norwegian government imposed a levy on $CO_2$ emissions on the Norwegian Continental Shelf. This led Statoil to invest in CCS on the Sleipner platform in 1996. In 1997 Norway signed the Kyoto treaty which triggered the creation of the first R&D program for CCS (KLIMATEK) in the same year, a predecessor to the CLIMIT Program.

The CLIMIT Program was established in 2005 to provide financial support of RD&D on CCS technologies. Research institutions and companies in Norway together with international partners may apply to CLIMIT for funding of their projects. The program is funded by the Norwegian government with an annual budget of € 24 million.

CLIMIT has so far provided € 120 million to about 200 projects covering basic research, technology development and pilot scale demonstration projects. In figure 2 the CLIMIT RD&D portfolio distribution is illustrated.

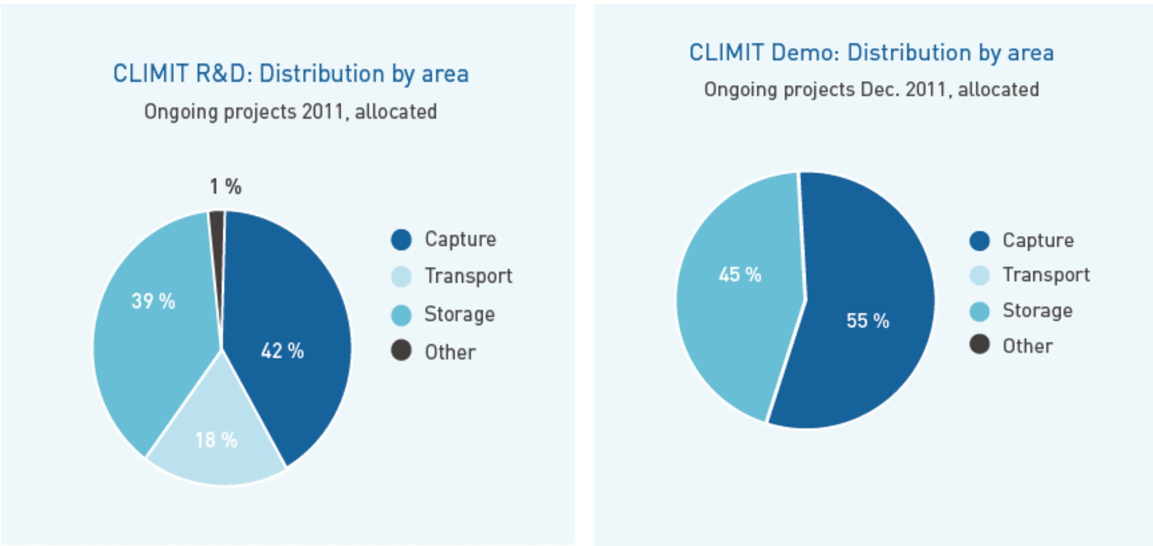


Fig. 2. CLIMIT RD&D portfolio distribution.

The maximum state aid available from CLIMIT is regulated by EU guidelines [8]. The aid intensity is generally lower for projects close to commercialization of products or services.

## 3. CLIMIT Program Achievements

### *3.1. External audit*

In 2011 the board initiated an external audit of the CLIMIT Program [9], which came to the following conclusions:

*The CLIMIT Program has been very important in stimulating relevant R&D-activities and there have been important achievements. Many interesting ideas and prospects for further R&D activities have been developed. Some of the research activities are within areas which could turn out to be next generation technologies with applications also outside the CCS value chain.*

*CLIMIT-funded research has 'narrowed', rather than closed the knowledge gaps and has provided options for improved performance of CCS systems. Whilst causality is difficult to prove, the steady progress made by Norwegian stakeholders working with international partners may have reassured policymakers and businesses on the likely viability of CCS, and this has helped support the case for financing CCS demonstration.*

*Therefore, the CLIMIT Program can be said to have made the prospects of global CCS deployment more likely than would have been the case without, and maintained Norway's position in many aspects of CCS.*

### *3.2 CLIMIT project examples*

Three important CLIMIT funded projects are briefly described below,

- Solvents for the next generation of post combustion $CO_2$ capture systems (SOLVit)
- Subsurface Storage of $CO_2$ - Risk Assessment, Monitoring and Remediation (RaMoRe) and
- $BIGCO_2$ R&D platform ($BIGCO_2$).

The objective of the SOLVit project is to develop more environmentally friendly and energy efficient solvents for post-combustion $CO_2$ capture. The target is to reduce energy consumption in the stripper by 50 % by 2016. A reduction of 35 % was achieved by the end of phase 1 in 2011. Project responsible is Aker with research partners SINTEF and the University of Science and Technology in Trondheim and industrial partners Statkraft, Scottish Power, EON and EnBW. The project period is 2008-2016 and total project cost is estimated to € 43 million.

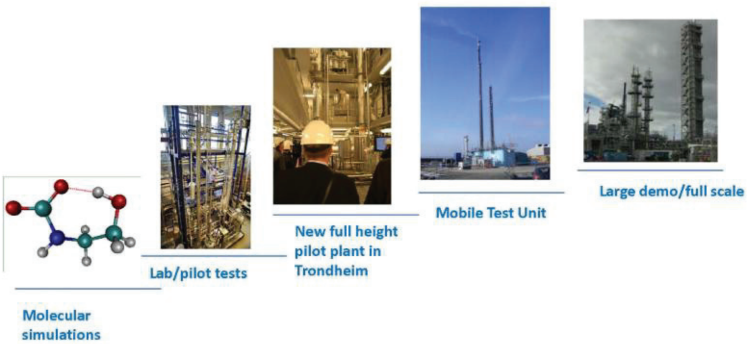


Fig. 3. The SOLVit project – from molecular science to full scale application.

The object of the RaMoRe project was to establish technology for risk assessment and monitoring of $CO_2$ storage. The project has also addressed potential leak mechanisms, as well as sealing properties of caprocks and hydrates. Experiments on cap rocks and well cement have provided new knowledge combined with theoretical analyses and modelling. Testing of well cement has shown that the risk of induced leakage pathways along the wellbore seems to be marginal. Diffusion of $CO_2$ into caprock will take place, but changes in geochemical behaviour are thought to be limited, which means that caprock integrity will be preserved. Project responsible was the University of Oslo with research partners Institute for Energy Technology, Norwegian Geotechnical Institute, University of Bergen and industrial partners Statoil, ConocoPhillips, Shell, Schlumberger, RWE-DEA. The project period was 2007 – 2012 and the total project cost was € 4.3 million.

BIGCO$_2$ was an international collaborative research project aiming at developing several enabling technologies and innovative solutions supporting a large-scale deployment of $CO_2$ capture from power generation and underground storage of $CO_2$. The project was coordinated by SINTEF Energy and co-funded by nine industrial partners. All main routes for $CO_2$ capture were investigated in addition to enhanced oil recovery and whole CCS value chain analysis. The project has developed new knowledge and technology that has moved CCS closer to demonstration. In addition, new R&D infrastructure facilitating vital experimental activities has been acquired between the R&D partners and a new generation of highly skilled researchers (PhDs and post. docs) has been educated. BIGCO$_2$ has been a steppingstone for establishment of several innovation projects, including SOLVit. The project period was 2007-2011 and the total project cost was € 14 million. Project responsible was Sintef with partners NTNU, Conoco/Phillips, DLR, Aker Solutions, Alstom, General Electric, Shell, Statkraft, Statoil and Total.

## 4. The CLIMIT Strategy Process

The strategy process focused on two different perspectives: a commercial, identifying drivers and barriers for CCS and a technological; identifying current technology status and potentials. The work included workshops with external experts and members of the CLIMIT program board. Seven foundation reports constitute the basis for the new CLIMIT strategy described in chapter 5:

1) Brief Technology Status and Potential.
2) Market Analysis.
3) Cost of CCS.
4) Policies and Regulations.
5) International Energy and CCS Roadmaps.
6) Current Infrastructure and Test Sites.
7) Innovative Processes.

Findings from these foundation reports are summarized below:

### 4.1. Brief Technology Status and Potential

Absorption into amine solvents is the most developed post combustion technology. Other developed technologies are based on amino acid salt and carbonate solvents. There are also other promising concepts under development which may be commercial after 2020, such as membrane based processes.

Promising pre-combustion technologies are Combined Cycle Gas Turbine (CCGT) combined with reforming of natural gas and also Integrated Gasification Combined Cycle (IGCC) combined with $CO_2$ removal after the shift reaction using physical solvents. Within oxyfuel, there is research on new methods for separation of oxygen from air and new concepts with other oxygen carriers, e.g. Chemical Looping Combustion.

Today $CO_2$ is routinely transported in both pipelines and by ship. A set of factors has been identified which may reduce investment and operation cost and improve safety and operational reliability. Among these are clarifying the influence of impurities on various transport related properties of $CO_2$, validation of models for dense phase $CO_2$ releases and some corrosion related issues. Intermediate storage facilities for $CO_2$ (“hubs”) will most likely be important in future integrated transport systems.

$CO_2$ storage in aquifers is proven technology. There is however a lack of suitable monitoring methods to completely fulfill all international requirements. Regulations are partly available regarding sub-sea storage and storage surveillance [10], [11]. However, it is a fact that the fear of leakage has created skepticism among the population in several countries. Information and experience with safe storage is required in order to achieve public acceptance. Actual demonstration projects of $CO_2$ storage are therefore important. Development of $CO_2$ storage technology should seek to maximize the utilization of available storage capacity while keeping the pressure buildup under control. In a Norwegian context it is important to evaluate how Enhanced Oil Recovery (EOR) can be combined with $CO_2$ storage in order to accelerate early realization of CCS.

Minor emissions of amines and degradation products to the atmosphere may be an environmental challenge for amine based $CO_2$ capture. The CLIMIT program has been central in supporting and funding research within this area, and the $CO_2$ Technology Centre Mongstad (TCM) and the Full-scale $CO_2$ capture Mongstad (CCM) have further developed and utilized this knowledge [12]. TCM received a discharge permit from the Norwegian Climate and Pollution agency autumn 2011 [13], and CCM has developed a technology qualification program for amine technologies which is currently being applied for five technology vendors.

For $CO_2$ transport, the main environmental uncertainty is connected to consequences of large $CO_2$ emissions. For $CO_2$ storage, it is important to study local environmental effects of small and large leakages.

### *4.2. Market Analysis*

The analysis covered the Norwegian market and looked at participants' involvement in CCS and in research projects funded by CLIMIT. The analysis divided participants into the following three main categories:

1) Owners of point sources and potential users of CCS technologies
   a. Oil companies
   b. Power companies
   c. Other land based industries
2) Technology suppliers and service providers
3) Research institutions

Most oil companies consider CCS as an enabling technology for oil & gas production, and not a business area in its own right. The most common examples of CCS as an enabling technology are separation of $CO_2$ from produced natural gas and enhanced oil recovery (EOR). CCS technology could also be important for the oil industry in a future carbon neutral market. Statoil and Shell have been the most frequent oil companies in CLIMIT projects, and they are also part-owners of the $CO_2$ Technology Centre Mongstad (TCM) where Aker Solutions and Alstom have begun testing of their amine and chilled ammonia capture technologies.

Fig. 5. $CO_2$ Technology Centre Mongstad (TCM), Aker amine plant (right) and Alstom chilled ammonia plant (left)

Power companies and other land based industries have shown modest participation in CLIMIT. Two-thirds of the power company participants have been non-Norwegian companies. Other land based industries in global competitive markets are reluctant to invest in CCS. Norcem, owned by Heidelberg Cement, is so far the only company in this category that runs a CLIMIT project. They plan to build capture pilot plants at one of their cement factories in Norway.

Technology vendors are the second most frequent group of participants in CLIMIT projects. As previously mentioned, Aker runs the one of the largest CLIMIT projects. There are a few big technology vendors in the CLIMIT portfolio, but the majority of participants in this category are small start-up companies. Their main challenges are limited financial resources, market uncertainty, and finding partners which can help them bring their innovations to market.

Norwegian universities and research institutions are the most frequent group of participants in CLIMIT funded projects. Some international universities and research institutions have also participated in these projects. Norwegian research institutions are at the forefront of CCS research, in demand as partners in international research consortia competing for international research funding. Their main challenge is to find industrial partners which can co-finance their projects.

### *4.3. Cost of CCS*

A full scale CCS facility solely for environmental purposes has yet to be built, and the cost estimates of such facilities have high uncertainties. Experience from desulphurization of flue gases from coal fired power plants in the seventies showed that the cost was underestimated before the first facility was constructed, but the cost fell close to 50 % after a decade or so based on learning, technology developments and process improvements. This is also in line with findings from other studies on introduction and deployment of new technology.

Recent international cost estimates show a trend of rising costs, indicating a cost per ton $CO_2$ avoided of € 100 per ton, and cost estimates of Norwegian projects have been even higher. On the other hand, a ZEP [14] report from 2011, based on updated experiences from the industry, indicates that the cost per ton $CO_2$ avoided may fall to around € 40 for new coal fired power plants with CCS after 2025.

The cost of CCS is a main barrier for large scale deployment. Cost reductions are achieved through early demonstration where learning is shared and process optimization is focused. In addition, extensive R&D for next generation technologies should be prioritized.

### *4.4. Policies and Regulations*

The regulatory framework necessary for implementation of CCS in full scale is under development but not in place for commercial decisions. Internationally binding agreements on climate change is unlikely to be agreed until 2020 and the $CO_2$ allowance price is too low to create demand for CCS as an environmental technology. Weak market demand leads to a gap between political ambitions and achieved results. In several European countries there is public resistance against onshore geological storage of $CO_2$. The low $CO_2$ allowance price is another factor that has reduced the EU’s ambition of 10-12 CCS demonstration plants by 2016 to five or less. Successful implementations of demonstration projects are important to assure development of efficient technologies as well as public acceptance. The main drivers of CCS projects in Europe have been environmental concerns, while the main drivers in North America have been EOR and security of energy supply.

Despite significant public funding for CCS projects internationally, only projects in the US and Canada have made investment decisions to develop full scale CCS chains. Public support schemes from EU (NER300), the Dutch government, the UK government and the Norwegian government may also lead to successful implementation of full scale CCS chains in Europe within this decade.

The Norwegian government has put in place certain regulations which could push investments in CCS. CCS is a political requirement for all new onshore gas power plants. In the Petroleum regime, a levy on $CO_2$ emissions from offshore oil & gas installations came into force in 1991 and will be increased from 2013. The levy contributed to the implementation of $CO_2$ storage on the Sleipner and Snøhvit installations, where the commercial drivers already were strong.

The CLIMIT Program is subject to state aid regulation which limits the intensity of its funding [8]. Basic research projects can be 100 % funded while for projects classified as industrial development and demonstration the typical limit of state aid intensity drops to 50 % and 25 % respectively. Industrial funding of the remaining 50 – 75 % is challenging, when projects even closer to commercialization, like the EU CCS demo-projects, may receive up to 100 % public support. It may become necessary to adjust this imbalance to increase the attractiveness of the CLIMIT program towards projects in the demonstration phase.

### *4.5. International Energy and CCS Roadmaps*

The importance of CCS as a climate change mitigation measure is clearly stated by the IEA. IEA's Roadmap [4] includes 100 full scale CCS chains internationally by 2020. Without CCS, the cost of achieving the two degrees target will increase by 70 % according to the IEA. The EU Energy Roadmap 2050 concludes that CCS may contribute 32 % of the targeted $CO_2$ reduction in Europe. These roadmaps underline the relevance and the need for funding programs like CLIMIT.

### *4.6. Current Infrastructure and Test Sites*

Norwegian authorities have supported the establishment of several CCS test sites for R&D in Norway. There are test facilities for post combustion $CO_2$ capture with capacity from 0.01 to 10 ton $CO_2$ per hour. The facilities are primarily for testing of solvents, but substantial investments has also been made in Chemical Looping and Oxyfuel facilities. For $CO_2$ transport, rigs and pipe loops are established to investigate two phase flow in general, and there are dedicated installations to investigate depressurization, heat transfer and corrosion. There are two storage pilots under development where the migration of injected $CO_2$ and different surveillance methods for leakages will be tested. In addition test sites and laboratory infrastructure for fundamental and applied research on CCS have been built up during the last years.

The $CO_2$ Technology Centre Mongstad has a third test site available, and this may be dedicated for smaller pilot plants. At an industrial scale, $CO_2$ capture from the natural gas production at Sleipner and Melkøya (Snøhvit) are important arenas for further research and verifications.

Internationally, ECCSEL (European Carbon Dioxide Capture and Storage Laboratory Infrastructure), which is planned to be operational from 2015, will be central. The Norwegian University for Science and Technology (NTNU) in collaboration with SINTEF will have the responsibility for coordinating the European laboratory infrastructure for $CO_2$ capture and storage.

### 4.7. Innovative Processes

High investment and operational costs are the main challenges for CCS. Development of CCS will require fundamental research and testing of various technologies in lab scale and small pilots in cooperation with industrial players willing to invest in this type of technology. Innovation must also be strengthened through international and interdisciplinary cooperation.

CCU (Carbon Capture and Utilization) is currently being introduced as a possible solution for development of CCS with an inherent commercial incentive. This may encourage new R&D communities to contribute to the development of innovative and cost efficient CCS technologies. At present there is no clear "technology winner" for $CO_2$ capture. Thus, the CLIMIT program may also explore the possible solutions that emerge from ongoing developments of CCU applications.

### 4.8. Summary of findings

The foundation reports from the strategy work highlight a number of factors and developments that have to be overcome for CCS to be deployed as an environmental technology. There is still no clear winner among the developed capture technologies and CCS is generally not economically viable as an environmental technology. This serves as the main barriers against deployment of CCS, and demonstration plants need to be built in order to prove the concept and gain public acceptance.

Land based industries are reluctant to invest in CCS because of cost and risk. "Wait and see" seems the better option in the absence of global agreements on emissions reductions and a global price on $CO_2$ emissions of consequence. This in turn makes it hard for research institutions and smaller technology vendors to find industrial partners to help them develop their CCS projects.

Fortunately, it's not all gloom. "Petroleum driven" projects such as $CO_2$/natural gas separation and EOR seem to be the best way forward for CCS, as witnessed in North America, where such projects are under construction. This makes oil & gas companies key players in the development of CCS. They have both the competence and resources required to develop CCS technology for use in their projects. Hopefully, these petroleum driven projects will benefit CCS as an environmental technology.

$CO_2$ storage in aquifers is proven technology, while monitoring technology needs to be developed further. Norway has the potential to develop a central European $CO_2$ storage system on the Norwegian Continental Shelf.

## 5. Conclusion – the CLIMIT Strategy 2012-2020

### 5.1. Main Objectives

The overall goals for the CLIMIT Program are:

1) Cost reduction and early international implementation of CCS
2) Implementation of CCS in Norway
3) Utilization of the $CO_2$ storage potential in the North Sea

A broad implementation of CCS depends on market players seeing a business opportunity for the technology. Research institutes need to be involved, but with the industry as a "demanding customer", giving priorities based on their needs. Development of innovative solutions and next generation technologies with lower costs is a priority in the CLIMIT Program. This requires fundamental understanding of the processes, interdisciplinary and international collaboration in combination with commercial drivers.

Another priority for the CLIMIT program is to focus on areas where Norway has a competitive edge. The Norwegian Continental Shelf has a substantial storage potential that can be used to store $CO_2$ from other European countries. Utilization of $CO_2$ in the petroleum industry, by e.g. gas-separation and EOR, can drive development of $CO_2$-chains. Norwegian supply industry and research institutions can provide competitive services to national and international industry. $CO_2$ can also be utilized in products such as minerals. In this aspect Norwegian process and mining industries can contribute. There is also significant $CO_2$ infrastructure (laboratory infrastructure, test pilots, storage pilots, $CO_2$ Technology Centre Mongstad) available in Norway. CLIMIT-supported projects should contribute to utilization and further development of this research infrastructure, as well as collaborative international laboratory infrastructure.

Two aspects distinguish Norway from other countries within CCS. While there has been public resistance to onshore storage in continental Europe, there has so far been limited public resistance to offshore storage of $CO_2$ in Norway. Statoil has been storing $CO_2$ from the Sleipner platform for more than ten years to few objections. The other aspect is that onshore $CO_2$ emissions in Norway come almost entirely from other sources than the power sector. These emissions have different flue gas compositions than coal power plants. $CO_2$ capture from gas power plants is particularly relevant because Norway is a major exporter of gas to Europe. Stricter emission requirements may require $CO_2$ capture from gas power plants. Development of capture technology for gas power plants is one of CLIMIT's main priorities.

### *5.2. Technology priorities*

Based on CCS technology status, the overall goals and strategy, guidelines for the thematic priorities within capture, transport and storage, including environmental RD&D, are formulated. In addition to priorities within the thematic areas, CLIMIT will also prioritize new concepts that integrate carbon capture and storage through the use of $CO_2$.

The program will focus more on basic research and development related to the next generation capture technologies. Near term ambitions are to test new promising capture technologies at lab scale and establish pilots for capturing $CO_2$ from industrial sources by 2016. Carbon negative concepts including Bio-CCS should be developed. Furthermore, it is a target to bring forward new technology to be tested at demonstration scale at the $CO_2$ Technology Centre Mongstad by 2020.

In the field of environmental R&D the 2016 target is to ensure that full scale post combustion $CO_2$ capture can be carried out with negligible environmental impacts. This means that technology for emission control of amines must be operational in full scale plants. In addition, procedures and models for environmental impact assessment should be developed. By 2020 methods and standards to handle all environmental assessments related to CCS should be in place.

## References

[1] Statistics Norway, http://www.ssb.no/english/subjects/01/04/10/klimagassn_en/
[2] Meld. St. 21 (2011-2012), Melding til Stortinget (Norwegian language), Norsk klimapolitikk, http://www.regjeringen.no/nb/dep/md/dok/regpubl/stmeld/2011-2012/meld-st-21-2011-2012.html?id=679374
[3] The Ministry of Petroleum and Energy and the Norwegian Petroleum Directorate International, Facts 2012 - The Norwegian petroleum sector, http://www.npd.no/en/Publications/Facts/Facts-2012/
[4] Energy Agency (IEA), Carbon Capture and Storage Roadmap, http://www.iea.org/publications/freepublications/publication/CCS_roadmap_foldout.pdf
[5] NPD (Norwegian Petroleum Directorate) 2011, $CO_2$ Storage Atlas North Sea
[6] TCM ($CO_2$ Technology Centre Mongstad), http://www.tcmda.com/en/
[7] The Norwegian CLIMIT Program for funding of RD&D of CCS technology, http://www.climit.no/?language=UK
[8] EEA state aid guidelines, Guidelines on the interpretation of Article 61 EEA, http://www.eftasurv.int/state-aid/legal-framework/state-aid-guidelines/
[9] Hansen, T.B. et. al. Evaluation of the CLIMIT Program, Oxford Research AS, Kristiansand 2011.
[10] The OSPAR Convention (The Convention for the Protection of the marine Environment of the North-East Atlantic), http://www.ospar.org/
[11] The London Convention (The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972) http://www.imo.org/OurWork/Environment/SpecialProgrammesAndInitiatives/Pages/LondonConvention-and-Protocol.aspx
[12] Gjernes, E. et. al. 2012, Health and environmental impact of amine based post combustion $CO_2$ capture, pending paper, GHGT-11
[13] TCM discharge permit (in Norwegian language), Norwegian Climate and Pollution agency, autumn 2011, http://www.tcmda.com/Global/Dokumenter/Tillatelse%20TCM.PDF
[14] ZEP (Zero Emissions Platform), http://www.zeroemissionsplatform.eu/